CEVE 411 / 511
ATMOSPHERIC PROCESSES
FALL 2016

Meeting Times and Location:
M/W/F 9:00-9:50 a.m., Mech Lab 251

Instructor:
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Office Hours:
Thursdays 1:30–3:30 pm. Office visits are also welcomed at other times by appointment.

Course Description:
This course will explore the chemical and physical processes that govern the formation, transformation, and transport of gases and particles in the atmosphere. The primary phenomena of focus will be atmospheric transport; global climate change; stratospheric ozone depletion; tropospheric ozone formation and related oxidant and reactive nitrogen chemistry; acid deposition; particulate matter; and mercury and other air toxics. While our primary focus will be the atmospheric chemistry and physics processes that influence these phenomena, we will also consider the broader context of environmental policy, control technologies, and impacts on human health and the environment.

Course Objectives and Expected Learning Outcomes:
Students completing this course will be able to:

1. Solve equations and simplified models representing physical and chemical processes in the atmosphere
2. Describe the photochemical processes that destroy stratospheric ozone and form tropospheric ozone under a range of conditions
3. Diagram the processes influencing Earth's radiative balance
4. Compare and contrast the challenges posed by air pollution, ozone depletion and climate change, and key policies that have been enacted to address them
5. Critically review published literature regarding the current state of scientific understanding for climate change and air pollution

The course addresses the following ABET student outcomes for the BSCE degree:

(a) an ability to apply knowledge of mathematics, science, and engineering;
(b) an ability to design a system … to meet desired needs within realistic constraints such as economic, environmental, social, political, … and sustainability;
(e) an ability to identify, formulate, and solve engineering problems;
(g) an ability to communicate effectively;
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
(j) a knowledge of contemporary issues

Prerequisites:
Students are expected to have a background in the fundamentals of chemistry, physics, and calculus, equivalent to CHEM 121/122; MATH 101/102; and PHYS 101. Please contact the instructor if you have questions regarding your preparation.

Textbook and Readings:
Daniel Jacob. *Introduction to Atmospheric Chemistry*. Princeton University Press, 1999. (available as pdf at http://acmg.seas.harvard.edu/publications/jacobbook/index.html)
[Recommended for students continuing in atmospheric science: John Seinfeld and Spyros Pandis. *Atmospheric Chemistry and Physics, Third Edition.* 2016.]
Additional readings will be made available on the Canvas website for the course.

Honor Code Policy:
All students are expected to adhere to the Rice Honor Code. The following specific expectations apply to this class:

- Exams will be given under the honor system and must be entirely a student's own work, using only resources that are explicitly authorized for that exam.
- Problem sets may be discussed with other students but must be written individually by each student in their own words.
- Plagiarism is unacceptable. Specifically, for all written work using references, students must both cite references used and express all ideas in their own words. Any direct quotation must be explicitly noted in quotation marks.

Disability Statement:
If you have a documented disability that will impact your work in this class, please contact me to discuss your needs. Additionally, you will need to contact the Disability Support Services Office in the Allen Center.

Grading:
Students will be evaluated by their performance on the following:

Assignments (6-8)	20%
Midterm Exams (2)	30%
Final Exam	25%
Presentations and final paper	25%

Assignments are due in class on the due date unless otherwise specified. Some will have additional problems for CEVE 511 students. Late assignments will incur a penalty of 25 points and will not be accepted after solutions are distributed.
Exams will be given on a take-home basis.
Presentations will include students presenting about recent news articles or policies (CEVE 411) or scientific articles (CEVE 511) throughout the semester, and an in-depth presentation or poster accompanied by a **brief paper** (4-6 pages) at the end of semester. Final grades may be adjusted by up to ±3 points based on **attendance and participation**.

SCHEDULE (*subject to change*)

DATE	THEME	TOPIC	READING
8/22	**Introduction to the Atmosphere**	Importance of the Atmosphere	
8/24	**Atmospheric Transport and Meteorology**	Structure of the Atmosphere (measures of composition; layers; pressure; barometric law)	Jacob Ch. 1, Ch. 2
8/26		Simple Models of the Atmosphere	Jacob Ch. 3
8/29		Horizontal Transport (Earth-Sun geometry; Coriolis force)	Jacob Ch. 4.1
8/31		Horizontal Transport (friction; Hadley and general circulation)	Jacob Ch. 4.1-4.2
9/2		Vertical Transport (buoyancy; stability; inversions; cloud formation)	Jacob Ch. 4.3
9/5	**LABOR DAY (no class)**		
9/7		Vertical Transport (cont.); Turbulence and Diffusion	Jacob Ch. 4.4
9/9		Tropical cyclones and El Niño; **Discussion:** News & scientific articles on meteorological phenomena	Readings on Canvas
9/12	**Climate Change**	Intro to Climate Change and its impacts	IPCC reading
9/14		Biogeochemical Cycles of Oxygen and Carbon	Jacob Ch. 6
9/16		Radiative Balance of the Atmosphere	Jacob Ch. 7.1-7.2
9/19		Greenhouse Effect	Jacob Ch. 7.3
9/21		Radiative forcing and climate response	Jacob Ch. 7.4-7.5
9/23		Natural climate variability; Aerosols and climate	Readings on Canvas
9/26		Mitigation, adaptation, and geo-engineering; **Discussion:** News & scientific articles on climate change	Readings on Canvas
9/28		Chemical kinetics and photolysis	Jacob Ch. 9
9/30		NO LECTURE: **MIDTERM 1**	
10/3	**Stratospheric Ozone**	Intro to Stratospheric Ozone; Chapman Mechanism ozone formation	Jacob Ch. 10.1; Readings on Canvas
10/5		Catalytic cycles of ozone destruction (NO_x, HO_x, halogens) and their interactions	Jacob Ch. 10.2
10/7		Ozone depletion at poles and beyond; Heterogeneous stratospheric chemistry	Jacob Ch. 10.3
10/10	**MIDTERM RECESS (no class)**		

DATE	THEME	TOPIC	READING
10/12		Policies for stratospheric ozone; **Discussion:** Recent news & scientific articles on stratospheric ozone	TBD
10/14	**Tropospheric Chemistry (Ozone)**	Intro to Tropospheric Ozone; Hydroxyl radical	Jacob Ch. 11.1
10/17		Basic NO_x cycle; Carbon monoxide and O_3 formation	Jacob Ch. 11.2
10/19		Methane: Sources, sinks, and oxidation	Jacob Ch. 11.2
10/21		VOC oxidation; NO_x- and VOC-limited ozone formation	Jacob Ch. 11.3, Ch. 12
10/24		NO LECTURE	
10/26		Daytime & nighttime NO_x and NO_y chemistry (including PAN & HONO); ozone production efficiency	Readings on Owlspace
10/28		Policies and technologies to control ground-level ozone; Houston ozone	
10/31		**Discussion:** Recent news & scientific articles on tropospheric ozone	
11/2	**Acid Deposition**	Acid deposition and its impacts; Natural acidity of rain	Jacob Ch. 13
11/4		Chemistry of sulfur and other gases influencing acid rain; Control policies and technologies	S&P Ch. 2.2; 7.3.3-7.3.6; 7.5; 22.1
11/7	**Air Toxics**	Mercury, Benzene, and other air toxics (**MIDTERM 2** assigned)	Readings on Canvas
11/9	**Particulate Matter**	Importance of particulate matter; Properties of particles	TBD
11/11		Visibility	S&P Ch. 15
11/14		Sulfate, Nitrate, and Ammonium Particles	TBD
11/16		Carbonaceous Particles	TBD
11/18		Policies and technologies to control particulate matter	
11/21		**Discussion:** Recent news & scientific articles on particulate matter	
11/23		TBD	
11/25		**THANKSGIVING RECESS**	
11/28	**Presentations**	Student posters and presentations	
11/30		Student posters and presentations	
12/2	**Synthesis and Review**	Synthesis of course material; Exam Review	
TBD	**FINAL EXAM**		